GEOLOGY OF THE DURST MOUNTAIN-HUNTSVILLE AREA

MORGAN AND WEBER COUNTIES, UTAH

by

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ABSTRACT

The Durst Mountain-Huntsville area is located about 35 miles northeast of Salt Lake City, Utah, and comprises nearly 110 square miles between Ogden and Weber Valleys. The formations exposed are the Precambrian Farmington Canyon complex; the Cambrian Tintic quartzite, Ophir shale, and Cambrian limestones and dolomites undifferentiated; Devonian Three Forks (?) formation; Mississippian Madison limestone and the Brazer formation; the Triassic Thaynes limestone; and the Tertiary Knight conglomerate, Norwood tuff, and Huntsville fanglomerate.

Three episodes of faulting were noted within the area. The Durst thrust is related to mid-Laramide activity. An east-west episode of normal faulting occurred during the Miocene (?). North-south normal faulting occurred during the Pliocene and Pleistocene.

The Herd Mountain erosion surface is the oldest erosion surface within the north-central Wasatch Mountains. It is dated as late Oligocene or Miocene age. A more recent erosion surface is the Weber Valley surface. The formation of this occurred in Pliocene or Pleistocene time. An arm of Lake Bonneville extended into both Ogden Valley and Weber Valley.

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INTRODUCTION

Location & accessibility

The Durst Mountain-Huntsville area described in this report covers an area of about 110 square miles in Townships 5 and 6 north, Ranges 1, 2, and 3 east, Salt Lake Meridian, Morgan and Weber Counties, Utah. It is a part of the north-central Wasatch Range as deliniated by Eardley (1944). The area is 30 miles northeast of Salt Lake City, Utah and 20 miles east of Ogden, Utah. Ogden Valley bounds the area on the north, Herd Mountain is approximately three miles west of the east line, Durst Mountain is on the south line, and the west line is about one mile west of the road between Mountain Green and Huntsville. (See index map, figure 1.)

The Durst Mountain-Huntsville area may be reached from Ogden, Utah, via either Weber or Ogden Canyon. A dirt road in Cottonwood Canyon traverses the area. To the south of Cottonwood Canyon "jeep" roads permit access to the base of the mountains; the peaks are inaccessible by jeep. North of Cottonwood Canyon roads that can be traveled by passenger cars permit fairly good coverage. This northern area can be reached via Utah Highway 39 west of Huntsville, thence south past the "Monastery" and east along Sheepherd Creek.

Purpose and scope

The Durst Mountain-Huntsville area was mapped by Eardley (1944) as part of a larger study of the geology of the

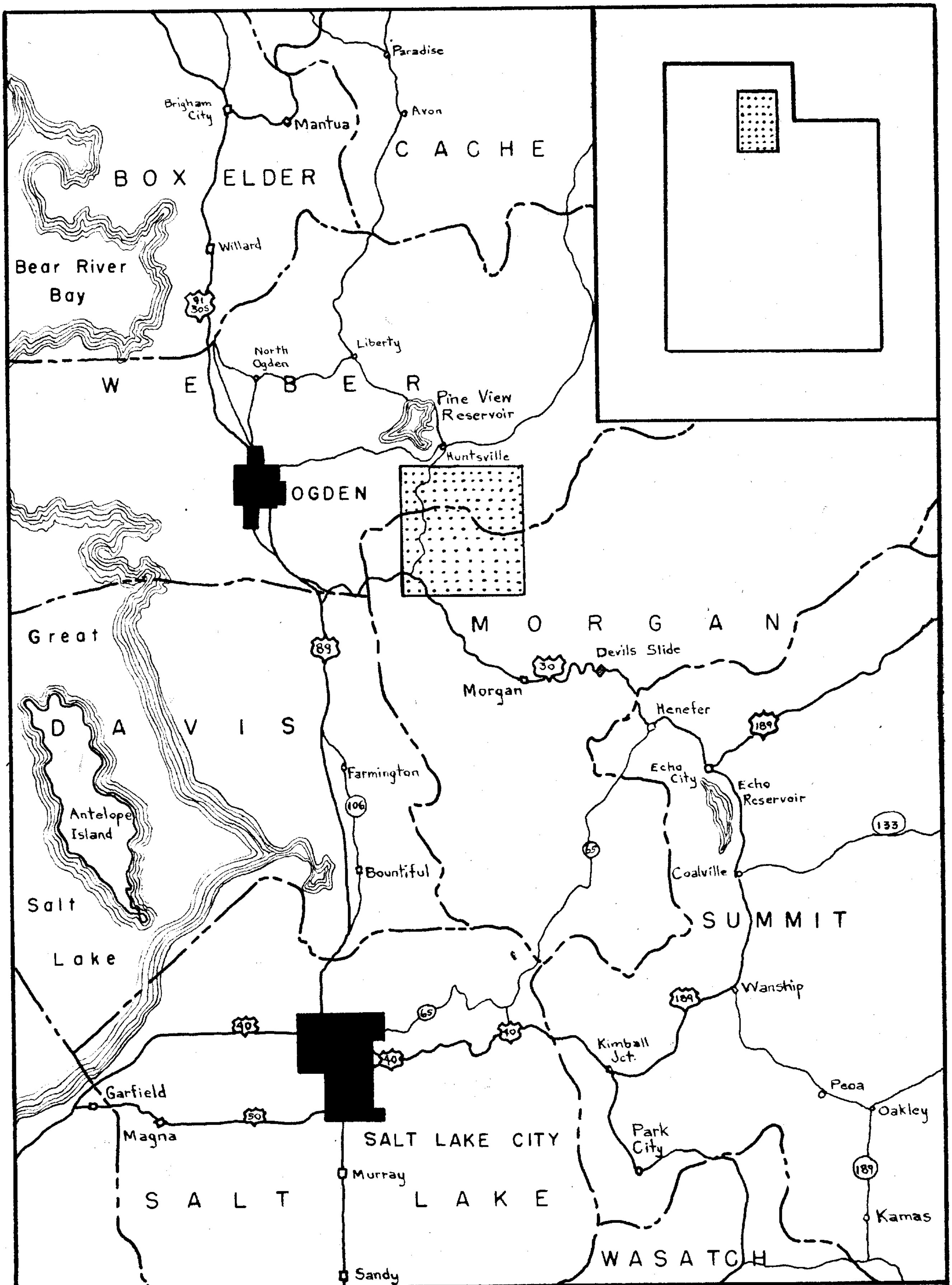

Fig. 1. Index map of the Durst Mtn.-Huntsville area

north-central Wasatch Mountains. The purpose of the present study is to remap the area in detail and particularly to study the details of the Tertiary history. Several theses have been completed by students at the University of Utah during the past few years under the direction of Dr. Eardley. Robert B. Schick (1955) made a geological study of the Morgan-Henefer area adjacent to the writer's area on the south. Ben E. Lofgren is studying Ogden Valley to the north-west and William Laraway has undertaken the geologic study adjacent to the present area to the northeast.

Field work

The study of the Durst Mountain-Huntsville area was begun in the early summer of 1956. Field work continued through the summer and fall of 1956, and was completed during the early summer of 1957. Field mapping was done on aerial photographs obtained from the United States Soil Conservation Service. The geology was transferred to the U. S. Dept. of Agriculture, Soil Conservation Service Planimetric base maps Utah-45 and Utah-46.

Geologic setting

The Durst Mountain-Huntsville area is part of the Middle Rocky Mountain physiographic province. More specifically it is included in the north-central Wasatch Mountains as deliniated by Eardley (1944).

The structural complexity of this area has long been known. The Wasatch Front is composed of a Precambrian mass which acted as a "nucleus around which compressional structures in the younger overlapping stratified rocks are shaped." (Eardley, 1944, p. 847). Thrusting is conspicuous around the northern and northeastern portion of the range near Ogden whereas folding predominates on the south. The Uinta uplift extends eastward from the southern limit and an "L" is formed with the north-south trending crystalline mass. Tertiary folding occurred in the angle of the "L" near Henefer and Coalville. The thrusts at the northern edge of this Precambrian crystalline complex are at right angles (approximately) to the folds of the Idaho-Wyoming area.

Excellent exposures of the thrusts and the crystalline complex can be seen in the canyons cut by the westward flowing Ogden and Weber Rivers which are respectively north and south of the Durst Mountain-Huntsville area. Because of these rivers the area is well drained. And if it were not for the rivers, a high plateau would probably be present east of the Wasatch Front. However, islands of Paleozoic and Mesozoic rocks which are surrounded by a blanket of Tertiary sediments are now in existence.

Previous geologic work

Stansbury (1852) visited the north-central Wasatch Mountains when, in search of a new route through the Rocky Mountains, he passed through Ogden's Hole (Ogden Valley) and

Ogden Canyon. Engelmann (1876) was probably the first qualified geologist to visit the area. Although he studied the geology of the East Canyon area in 1858 and 1859, his discoveries were withheld from publication until 1876. Following Engelmann were the early Territorial surveys of the Rocky Mountain Region. Bradley (1872), who was with the U. S. Geological Survey of the Territories, made observations of the "Wahsatch" Mountains from Ogden to Fort Hall, Idaho. Gilbert (1875) visited the "Wahsatch" Range as part of his contribution to the Survey West of the One Hundredth Meridian. Hague and Emmons (1877) of the 40th Parallel Survey presented a general discussion of the Wasatch Range. They made a traverse from Huntsville to Mountain Green and also recognized the Paleozoic rocks in the vicinity of Durst Mountain. Gilbert (1890) in his classic Monograph on Lake Bonneville noted the presence of lake sediments in Ogden and Weber Valleys. He also described an old fault scarp near the town of Morgan.

During the early 1900's coal and oil studies by Veatch (1906, 1907) provided a better understanding for the Cretaceous and Tertiary systems of the region. Boutwell (1907) contributed fundamentally to the stratigraphy in his study of the Park City mining district. The study of phosphate deposits by Weeks and Ferrier (1907), Blackwelder (1910a, 1910b), and Gale and Richards (1910) furthered the geologic knowledge of the region. B. S. Butler (1920) briefly described the ore deposits within the area.

Hintze (1913), Eardley (1933, 1934, 1944), J. Stewart Williams (1943, 1945, 1948), Mathews (1931), and Kummel (1953) have contributed considerable detail to the stratigraphy, structure and physiography of the north-central Wasatch Mountains. Also, a number of excellent theses describing local areas have been written by University of Utah students under the direction of Doctors A. J. Eardley and Norman C. Williams.

GEOGRAPHY

Topography

For the most part the Durst Mountain-Huntsville area is composed of rolling hills and flat uplands, but along the strike of the Paleozoic formations in the vicinity of Durst Mountain and Elk Mountain the terrain is very rugged. There is about a 4,000 foot change in elevation from Cottonwood Creek to Durst Mountain in less than two miles horizontal distance. The highest peak in the area is Durst Mountain which attains an altitude of 9,265 feet. The lowest area is on the Weber River and the altitude at this point is 4,880 feet. The western portion is relatively low and forms a divide between Morgan and Ogden Valley.

Land utilization and vegetation

Most of the land of the Durst Mountain-Huntsville area is included in the Cache National Forest, but some small portions are privately owned. The land is primarily used as the summer range for sheep. Several herds of about 1,000 sheep per herd are grazed in the area every summer. Turkeys are raised in the lower parts of Cottonwood Canyon. Cattle grazing accounts for a minor part of the land utilized. The only land under cultivation is in the western part of the area. Grain and alfalfa are grown. The farms are all on the Norwood tuff; a rich soil is formed from the tuff and wherever the land is level enough it is cultivated. The only "year-round" inhabitants live on these farms.

The foothills and the south and west slopes of the area are generally covered by large sage-brush. Above the foothills scrub oak and mountain mahogany are dense and make hiking in such areas difficult. Quaking aspen are found in the canyons, and at higher elevations stands of the aspen are intermixed with Douglas fir, White fir, and Alpine fir.

Rock exposures

Rock exposures, generally, are scarce. The transverse canyon of Cottonwood Creek gives a fairly good cross-sectional view of the area. Elsewhere the prolific growth of scrub oak and mountain mahogany and the thick soil mantle prevents the direct tracing of beds over long distances. It was necessary to remove the mantle in places to determine the lithologies under foot and subsequently to map on the basis of soil types. Not only did the vegetation obscure the exposures but it also prevented the accurate location of a ground point on the aerial photographs, for the scrub brush was well over the writer's head which prevented the sighting of landmarks.

STRATIGRAPHY

The rocks present in the Durst Mountain-Huntsville area range from Precambrian to Quaternary. A core of Precambrian and Paleozoic rock crops out in the central part of the area. The strata are entirely sedimentary except for the Precambrian sequence which is wholly metamorphic. The Cambrian sediments are vertical or dip slightly to the east except where influenced by faulting. The Cambrian sequence is partly repeated by faulting. The Devonian, Mississippian and Pennsylvanian strata crop out east of the Cambrian but the dip of these formations is not so steep. A small area underlain by Triassic rocks was found north of Bennett Creek. The eastern part of the area is blanketed by Eocene conglomerates which rest unconformably on older rocks. The western portion is covered by Oligocene tuffaceous sediments which are in turn capped locally by a flat-lying Pliocene fanglomerate. Quaternary deposits consist of alluvium and lake sediments developed along the shoreline of Lake Bonneville.

Precambrian system

Farmington Canyon complex. The oldest rocks exposed in the area are a metamorphic crystalline complex. These rocks were designated by Eardley and Hatch (1940a) as the Farmington Canyon complex for the exposures in Farmington Canyon and at Bountiful Peak east of the town of Bountiful. They assigned a middle (?) Precambrian age to this sequence.

The Precambrian is generally eroded to a rolling topography but where it is in contact with the overlying Tintic quartzite very steep slopes are formed. The soil mantle covering the complex is usually very deep, generally reddish-brown, and contains an abundance of mica flakes. On heavily covered slopes and where outcrops were scarce, the mica float aided in determining the lithology underfoot. The outcrops of the gneisses and schists were usually extremely weathered and fresh surfaces were difficult to obtain.

The Precambrian is composed of gneisses and schists that are intruded by pegmatite dikes. The rocks are foliated and generally the banding is parallel to the bedding planes which are vertical. The pegmatites in Cottonwood Canyon are being prospected for radioactive and rare earth minerals. Thorium and Yttrium are reported by the prospectors to be present in the pegmatites but this was not verified. Mica is abundant in the pegmatites and the combination of radioactive material with the mica is the incentive for the continued prospecting. However, the low grade of the mica and uranium and the toughness of the host rock leads the writer to conclude that the mining of these commodities would be uneconomical. The writer, while doing reconnaissance work in the Precambrian exposures as mapped by Schick (1955) in the vicinity of Spring Hollow, found mica books ranging in size up to one inch across.

Much petrological work has been done on the

Farmington Canyon complex. Eardley and Hatch (1940a) were the first to make an intensive study of this formation. They also correlated (Eardley and Hatch, 1940b) the metamorphic crystalline complex of the Wasatch Mountains with that of Antelope Island. Detailed studies were made by Bell (1951) in the Farmington Mountains and Larsen (1957) on Antelope Island. Eardley (1944) designated the Precambrian of the Cottonwood Canyon* area also as the Farmington Canyon complex. The metamorphic complex consists of a stratified crystalline series of metasediments, metamorphic silicic igneous rocks, injection gneisses, and metamorphic mafic rocks (Eardley and Hatch, 1940a). They tentatively place this complex in the middle (?) Precambrian and postulate the deposition of over 10,000 feet of sediments followed by the injection of sills and dikes during a period of orogeny that was more intense than any subsequent deformation.

This metamorphic complex is normally overlain by a sequence of Proterozoic (?) strata composed of interbedded quartzite, phyllite, shale, arkosites, tillite, and limestones which is more than 12,000 feet thick (Eardley and Hatch, 1940b). This Proterozoic sequence is present a few miles to the north in the Canyon of the South Fork of the Ogden River

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* Cottonwood Canyon, unless so stated, refers to the east-west canyon of Cottonwood Creek, in the southern part of the area. It should not be confused with the Cottonwood Creeks east of Salt Lake City and those adjacent to the eastern border of the area.

(William Laraway, personal communication), to the east in the Uinta Mountains (Williams, N. C., 1953), and to the west and south (Eardley and Hatch, 1940b). However, these less metamorphosed sediments are absent in this local area. One explanation for the absence of the Proterozoic strata is to postulate an eastward extending arm of the Utah Highland (described by Eardley, 1939). Mapping by Eardley (1944) in the Wasatch Mountains west of the area under consideration does not reveal the presence of any Proterozoic strata. Therefore, it could be assumed that the Proterozoic strata were never deposited in the Durst Mountain-Huntsville area.

Cambrian system

General statement. The oldest sedimentary rocks recognized within the area are of Cambrian age. Sedimentation began with the deposition of coarse clastics which graded into finer sediments and was followed by deposition of chemical sediments. The total thickness is about 2,600 feet. The Cambrian system crops out in a north-south band passing through Durst Peak in the south-central portion of the area.

Throughout the western interior of the United States the Cambrian system can be divided into three parts: (1) a basal quartzite unit, (2) a relatively thin middle shale unit, and (3) an upper carbonate unit predominately of limestone. This represents a transgressive phase of the sea that started in lowermost Cambrian (or very late Precambrian) in California and southern Nevada and encroached upon the land from southwest to northeast. The Cambrian rests unconformably on the Precambrian metamorphic complex.

Tintic quartzite. The Tintic quartzite was named by G. O. Smith (1900) for exposures in the Tintic Mountains. The formation crops out in the south-central portion of the area and strikes generally north. Nearly everywhere the attitude of the Tintic is within a few degrees of the vertical. Good exposures may be observed west of Durst Peak and north of Cottonwood Creek.

The Tintic quartzite is a cliff forming hard and dense quartzite and quartzitic sandstone that is predominently pink and buff, but with shades of gray, red, purple and green. The quartz grains, which are cemented by silica, are medium-sized to coarse, well-rounded and have a glassy appearance. Frequently the rock will fracture through the grains as well as around them. Eardley (1944) states, "The secondary silica is in optical continuity with the quartz grains, but in the pink and red quartzites a thin iron oxide border surrounds most of the grains and enables the observer to distinguish the original grains from the added material." Most beds have a vitreous appearance but some are sugary.

Thin beds of intraformational conglomerates are common and numerous beds of grit, up to several inches thick, were observed. Cross-bedding was noted throughout the formation but no determination of prevailing direction could be made.

A coarse basal conglomerate, as noted by Eardley (1944), is well exposed in the vertical outcrop north of Cottonwood Creek. The pebbles are mostly well-rounded and range from 1 to 4 inches in size. The conglomerate is made up of varied colored and laminated quartzites which appear to be similar to the varieties of near-by Proterozoic (?) quartzite. Eardley (1944) reports that the basal conglomerate is thinner in Hardscrabble Canyon to the south and absent in Ogden Canyon. Norman C. Williams (1953) finds a basal conglomerate 1-3 feet thick at various locations along the base of the Tintic quartzite in the Uinta Mountains. He has compared this with the conglomerate at Cottonwood Creek and has found them to be "essentially identical".

Thin beds of brownish-buff, micaceous shale become increasingly common as the top of the formation is approached. Near the top, the shale attains a greenish cast with an increase of mica and appears to be almost schistose. This shale grades into the overlying Ophir shale. Worm borings(?) (probably formed by Scolithus) are common within 100 feet of the top of the Tintic. Worm trails (?) and rain drop imprints are common on the bedding planes of the shale.

The thickness of the Tintic quartzite in the Durst Mountain-Huntsville area is about 1,000 feet. It rests with angular discordance on the Precambrian Farmington Canyon complex and is conformably overlain by the Ophir shale. In adjacent areas where Proterozoic (?) quartzites are present, it is difficult to place the contact between the two. From observations in these areas, Eardley and Hatch (1940b) suggest that the contact is one of both conformity and disconformity.

By common usage the basal Cambrian quartzites north of the Ogden River are referred to as the Brigham quartzite, and Tintic quartzite is the terminology applied to those occurrences to the south. Many writers have described the basal quartzites and concluded that the quartzites are all part of a thick blanket that was deposited as the sea transgressed from west to east during the first Paleozoic invasion of the western interior. The formation crossed time boundaries as deposition extended eastward. The lack of fossils prevents an accurate dating of this formation. J. Stewart Williams (1948) assigns the Brigham quartzite of Logan Quadrangle to the Waucobian.

Ophir shale. The Ophir shale was named by G. F. Loughlin (1919) for exposures near the town of Ophir in the Oquirrh Mountains. In the Durst Mountain-Huntsville area it crops out east of the Tintic quartzite and is poorly exposed. Depressions are formed along the strike of the formation and a notch is present wherever the shale intersects a ridge. The best exposures are along the high ridge extending westward from Durst Peak, in the mouth of Durst Canyon, and on the steep slope north of Cottonwood Creek.

The Ophir shale represents a transition from clastic to carbonate deposition during the Middle Cambrian. Shale is the dominate lithology but quartzitic, sandy, arkosic and limy beds are present. The clastic layers are more common toward the base and the arkosic layers are present throughout the formation. The micaceous and wormy appearance of the shale is so distinctive that lithologic correlations within the Durst Mountain-Huntsville area are reliable. The Ophir shale is brown to greenish-gray with a particularly well-developed micaceous sheen on the parting surfaces. Most of the layers are fissile but some are heavy-bedded. East of Durst Mountain the Ophir shale is about 200 feet thick.

The Ophir shale is conformable with the units above and below it. The shaly beds at the top of the Tintic quartzite grade into the Ophir, and the limestones at the top of the Ophir grade into the overlying undifferentiated limestone.

Few fossils were found in the Ophir shale. Annelid (?) trails and fucoids (?) are common on the bedding surfaces. One excellent trilobite specimen was found near the base of the Ophir in the NW¼, NE¼, sec. 34, T. 5N, R. 3E. Inarticulate brachipods were the only other fossils found. Robert Bright, graduate student at the University of Utah, identified the following genera:

Glossopleura

Lingulella

Obolus

Dicellomis

Bright states that the lithology and the presence of *Glossopleura* suggest Middle Cambrian Spence shale or Ophir shale equivalents.

Wheeler (1943, p. 1813) states that the Pioche shale and the Ophir shale are formationally the same, but that the shales are progressively younger toward the east. It has been thought that the Ophir shale also correlates with the Spence shale of the Logan Quadrangle. The writer hesitates to make this correlation. Preliminary work by William Laraway (personal communication), working adjacent to the area of this report on the north, reveals a shale unit which he believes to be the Ophir shale overlain by about 50 feet of dolomite; the dolomite in turn is overlain by another shale unit which is possibly the Spence shale. He feels confident that both the Ophir and the Spence are much thinner than their correlatives either to the north or the south. Wheeler (1943, p. 1815) states:

> "If the Spence and Pioche shales are distinct the northern limit of the latter in north-central Utah is somewhere between Ogden and Blacksmith Fork, and somewhere south of Promontory Point."

It is possible that the Spence shale was deposited during a temporary regression of the sea which extended southward from the Logan area, to the Ogden River. This regression was after the west to east transgression during which the Ophir was deposited.

Cambrian limestones and dolomites. Above the Ophir shale is a sequence of limestones, dolomites, and shales that have been mapped as one unit. These rocks outcrop from the southern limit of the area to within a few miles of the northern limit. They are best exposed in the vicinity of Durst Mountain. The more resistant carbonate members which are separated by thin beds of shale are eroded into a succession of low ridges and depressions. For the most part the units are covered by a prolific growth of vegetation.

The basal member is a dark, almost black limestone that is mostly oolitic and pisolitic; weathered surfaces are dark gray-blue. Buff and brown mudstone material is distributed along the bedding surfaces and at closely spaced intervals these are connected by streaks normal to the bedding. The blotchy, mottled, and banded mudstone occurs in a variety of patterns at other horizons in the limestone. Small concretions of pyrite from one-eight to one-quarter inch in diameter are common. A vein of iron oxide can be traced along the strike of this unit from the base of the steep slope north of Cottonwood Creek to halfway up the slope. Just north of Durst Peak another occurrence of iron oxide was noted. Both of these locations are dotted with old prospect holes.

The persistence of the next younger units could not be determined for exposures were poor. Except for the outcrops west of Durst Peak, where Eardley (1944) measured this section, the sequence of lithology could not be determined. However, two distinct dolomite units were observed but the relationship between the two was not discernable. The first was a dark gray, black weathering dolomite that contained light colored rods and vermicular tube-like markings which are a quarter to half an inch in length and about one sixteenth of an inch in diameter. The second was a light-gray, finely laminated dolomite that weathered to a dull, chalky white.

The shales that are interbedded with the carbonate units are mostly thin-bedded and range from tan to olive-drab. The author found and identified Lingulella from a tan shale bed near the top of the formation. The only other fossils located in the sequence of limestones and dolomites were found in the road cut between the mouth of Durst Canyon and Miller's Gulch. The following genera were identified by the writer:

Obolus

Acrothyra

Lingulella

Eardley (1944, p. 829) measured 1,375 ± feet of Cambrian rock above the Ophir shale west of Durst Peak. These rocks are conformable with the Ophir shale, and also appear to be conformable with the overlying Devonian rocks although a considerable hiatus exists between the two systems.

The paucity of fossils prevented the writer from subdividing the Cambrian limestones and dolomites as was his original intention. Either of two systems of nomenclature could be brought into the area mapped, i.e., the Logan Quadrangle or the Stockton and Fairfield Quadrangles. With cursory study the Logan nomenclature would seem the most suitable for both areas are situated within the Middle Rocky Mountain Province and the strike of the Cambrian rocks is generally north toward the Logan Quadrangle. However, the author concurs with Eardley (1944) in favoring the Great Basin terminology. Gilluly (1932) in his study of the Stockton and Fairfield Quadrangles presented very excellent lithologic descriptions of the Cambrian formations. The author has compared these with the descriptions given by J. Stewart Williams (1948) and other students of the Logan area. Descriptions of the peculiar types of lithology, such as the blotchy and mottled limestones that occur within the Durst Mountain-Huntsville area could not be found in literature concerning the Logan area. However, Gilluly (1932) describes Cambrian rocks that are very similar to those found within the mapped area. The blotchy and mottled limestones and dolomites are very similar to the Hartmann and Bowman formations. The dark dolomite containing the vermicular tube-like marking is very similar to the "Bluebird type" as is the finely laminated dolomite to the "Lynch type". The writer realizes that definite correlations cannot be made until paleontological evidence is found. The writer is of the opinion that the similarity of these unusual sedimentary rocks is strong evidence for the correlation between the Durst Mountain-Huntsville area and the Great Basin.

Gilluly has assigned the Hartmann and Bowmann formations to the Middle Cambrian and the Lynch dolomite to the Middle and Upper Cambrian.

Devonian system

Three Forks (?) formation. The Three Forks (?) formation can be traced northward from the southern limit of the area mapped along the east slope of Durst Mountain to within three miles of the northern boundary. This soft Devonian formation weathers to a topographic low between the more resistant Cambrian and Mississippian limestones. North of Cottonwood Creek the formation was traced mainly on topographic evidence. The best exposures can be seen on the ridges leading to Durst Mountain, particularly the high ridge at the head of Miller's Gulch. However, nowhere was a complete exposure of the formation found; consequently, the lithology is not completely known. The Three Forks formation was named by A. C. Peale (1893) for the occurrences in the vicinity of Three Forks, Montana.

The Three Forks (?) formation is an earthy, red to tan, sandstone and shale unit. In places thin beds of limestone or dolomite can be found, especially near the bottom of the section. The basal limestones are considerably more arenaceous than the underlying Cambrian limestones; they are blotchy and somewhat mottled. Sandstone and shale are interbedded with the limestones and the formation grades upward into entirely clastic sediments. At the head of Miller's Gulch the sandstone and shale is brick-red; these clastic units are interbedded with thin layers of whitish weathering limestone. Conglomeratic beds composed of small red pieces of crumpled shale, embedded in a calcareous matrix, are common in the upper portion of the formation (Eardley, 1944). This particular type of conglomerate is believed to be diagnostic of the Three Forks.

At the head of Miller's Gulch the section was estimated to be 750 feet thick. The upper and lower contacts were not observed in the field but the similarity of attitudes of the underlying Cambrian limestones and the overlying Madison limestone, indicates that the Devonian is conformable with these formations although a considerable hiatus is represented by the lower contact. Edvalson (1947, p. 43) states that no marked angular unconformity is present between the Devonian and the Madison limestone in the central Wasatch Mountains.

No fossils were found in the Three Forks (?) formation; therefore, this formation can only be tentatively assigned to the Devonian system. According to Eardley (1944) the chief reason for assigning this group of beds to the Devonian stems from the work of Richardson (1913) in the Randolph Quadrangle. On the basis of paleontological evidence, Richardson was able to correlate the Three Forks of the Randolph Quadrangle with that of the type section. The lithologic similarity between the Three Forks of the mapped area and the Randolph Quadrangle, plus the fact that both are conformably below the Madison limestone are the criterior by which the correlation is made.

Edvalson (1947) postulates that a channel existed in Upper Devonian time which connected the central Wasatch area with the Randolph area. He states also that a positive area of low relief was present between Salt Lake City and Ogden during the Lower and Middle Devonian, and that this area acted as a source for the clastic sediments in this area. If this is correct, then the Three Forks of the mapped area must certainly correlate with the occurrences to the north.

J. Stewart Williams (1948) describes the Jefferson formation in the Logan area as containing two members, the upper of which is the Beirdneau sandstone. The lithologies of the Beirdneau member and the Three Forks formation of the

Durst Mountain area are similar and Brooks and Andrichuk (1953) correlate the two. They also state: "The Beirdneau member of the Jefferson formation may be chronologically a close correlative of the Three Forks formation".

Mississippian system

Madison limestone. The Madison limestone crops out at the southern limit of the area and strikes northward to Sheep Herd Creek. Cliffs of Madison limestone that are typical of this formation elsewhere are only locally present within the area. However, the Madison stands out as a fairly steep, rounded slope above the Three Forks formation. The Madison limestone was named by Peale (1893) for the Madison River in the Three Forks, Montana area, but he failed to designate a type area.

The Madison limestone is thin-to-medium bedded, medium to dark gray, and the texture is compact to granular. Some thin beds (up to 1 foot) are composed almost entirely of fossil fragments. The lithology of the Madison in this area is very similar to the section in the Logan Quadrangle (J. Stewart Williams, 1943); however, the lower black shale member is missing in the Durst Mountain-Huntsville area.

Eardley (1944) measured 650 feet of Madison limestone at the head of Miller's Gulch, east of Durst Peak. The lower 200 feet is dark gray, dolomitic limestone which contains a 2-foot vein of iron oxide and barite. Float of iron oxide and

barite can be found on the ridge east of Miller's Gulch and north of Cottonwood Creek along the strike of Cambrian limestone and dolomites. Therefore, a vein probably exists along the Spring Branch fault and is later than the fault, although the relationships are obscure. A 50 foot middle unit of pink argillaceous limestone overlain by 400 feet of dark gray, cherty, fossiliferous limestone completes the section.
J. Stewart Williams (1943) measured 755 feet of Madison limestone at the southern base of Durst Mountain.

The Madison limestone is conformable with the Three Forks formation and the Brazer formation.

The fauna of the Madison limestone has established an early Mississippian age (J. Stewart Williams, 1943; Holland, 1952). The following specimens were identified by Dr. William Lee Stokes:

Strapatollus sp.	Michelina sp.
Schuchertella sp.	Fenestellid bryozoan
Triplophyllum sp.	Productid brachiopods
Meekospira sp.	Crinoid fragments
Composita sp.	Cup corals

Stokes comments that this assembledge is probably Madison or Deseret equivalents. However, the fauna collected in the vicinity of Sheep Herd Creek is not diagnostic of the Madison, and Stokes (oral communication) thinks it might be better to call the limestone in this area undifferentiated Mississippian limestone.

Brazer formation. The Brazer formation is exposed from the Spring Branch fault to the southern limit of the area.

North of the fault the Brazer is mostly covered by the Knight conglomerate. The Brazer formation was named by Richardson (1913) for exposures in Brazer Canyon, Crawford Mountains, Utah.

The Brazer formation is composed of 600 feet of sandstone, tan to red, with some calcareous layers above which are about 100 feet medium gray finely crystalline limestones. The Brazer formation lies conformable on the Madison limestone. The base of the Brazer was mapped at the first sandstone on top of the Madison limestone. Because of the poor exposures, field identification of the Brazer was generally based on the presence of a sandy unit between the underlying Madison and the overlying Round Valley limestone and on paleontology.

Eardley (1944) correlated the Brazer formation of the Durst Mountain-Huntsville with that of the Logan Quadrangle. In the Weber Canyon area J. Stewart Williams (1943) assigned an age from Meramecian through late Chesteran time. Paleontological work by Sadlick (1955) led him to a re-evaluation of the Brazer formation northeast of Morgan. Sadlick found Pennsylvanian fossils in the upper three and part of the fourth units as measured by Eardley (1944, p. 832). Sadlick named a new formation, the Round Valley limestone, for these upper units and limited the Brazer to 700 feet of sandstone and limestone instead of the original 1,100 feet as measured by Eardley. Sadlick states that the Round Valley is conformably over the Brazer formation.

Pennsylvanian system

<u>General statement</u>. The Pennsylvanian rocks within the area are exposed south of the Spring Branch fault, except for a small outcrop of Weber quartzite (?) south of Bennett Creek. The Pennsylvanian rocks strike north; the Knight conglomerate covers these rocks to the north.

The heavy cover of mantle and vegetation prevented the author from accurately mapping the Pennsylvanian formations. Nowhere is any one of the Pennsylvanian formations completely exposed and, therefore, lithologic descriptions must be very general. The work of Schick (1955) to the south has aided the writer considerably in placing the contacts. The writer found the contacts as mapped by Schick and traced them northward.

<u>Round Valley limestone</u>. Walter Sadlick (1955) made a detailed study of the Mississippian-Pennsylvanian boundary in north-eastern Utah and as a result of his investigation named the Round Valley limestone formation.

The Round Valley limestone is a light-gray, cherty, and dolomitic limestone. It does resist erosion poorly and generally forms rounded hills. Sadlick reports that the Round Valley limestone thins from 395 feet in Round Valley, northeast of Morgan, to about 150 feet in Dry Bread Hollow, northeast of Huntsville. The fauna of the Round Valley limestone assures a lower Pennsylvanian age for the limestone. The limestone interfingers with sandstones at both the upper and lower contacts.

Morgan formation. The Morgan formation crops out east of the Round Valley limestone and is poorly exposed. Blackwelder (1910b) published the name Morgan that was given by F. B. Weeks for the red-beds below the Weber quartzite in Weber Canyon.

The Morgan formation is an earthy sandstone that is white to pink on a fresh surface, but weathers red. Thin beds of shale and limestone are present in the upper portion of the formation. Generally the formation is more thinly bedded in the lower portions than the upper portions. The Morgan formation is conformable with both the overlying and underlying formations.

Laraway (personal communication) states that the Morgan is probably absent to the north. Eardley (1944) states that the Morgan formation is about 1,000 feet thick at Round Valley. J. Stewart Williams (1943) assigns an early Pennsylvanian age to the Morgan formation in Round Valley.

Weber quartzite. A small area along the southern limit of the area and east of the Knight conglomerate is underlain by the Weber quartzite. A small exposure of Weber quartzite (?) is present in a road cut south of Bennett Creek. The Weber quartzite was named by King (1876) for exposures in Weber Canyon.

The Weber quartzite is a misnomer for this formation as it is mainly composed of sandstone with some quartzite beds. Minor amounts of limestone and dolomites are present especially near the bottom. The sandstones are fine to medium grained, thick-bedded to massive, and sometimes cross-bedded.

South of Bennett Creek a badly broken and brecciated zone of fine-grained, white, calcareous sandstone and brecciated limestone is exposed for about 50 yards, in a road cut. Dr. Eardley examined this outcrop with the writer and both conclude that this is probably Weber quartzite on the basis of lithology. This outcrop is exposed along the strike of the Bennett Creek fault.

J. Stewart Williams (1943) assigns a Lower Pennsylvanian age to the Weber quartzite. The Knight conglomerate overlies the Weber quartzite with angular discordance, but the underlying Morgan formation grades into the Weber. The Weber quartzite is 3,000 feet in Weber Canyon (Eardley, 1944).

Triassic system

Thaynes formation. The Thaynes formation crops out on the south side of a low hill, north of Bennett Creek. This small, isolated exposure is partially covered by debris of Knight boulders. Near the base of the hill a small road cut exposes a shale unit; above this only a few separate beds of limestone, perhaps each a foot thick, can be observed. The Thaynes formation was named by Boutwell (1907) from the Park City mining district of Utah.

A calcareous, tan, and earthy shale unit makes up the lower third of the hill. Ripple marks and rain-drop imprints are common. No fossils were found within the shale. Above the shale the limestone crops out which has yielded some fossils. The beds cannot be traced along the strike and a diligent search must be made in order to locate them. The limestones are tan to gray; the tan units are earthy.

Dr. Wm. Lee Stokes, who examined the fossil collections stated: "The fauna as well as the lithology of the specimens show that this collection is from the lower part of the Thaynes formation, Lower Triassic". He identified the following genera:

Ophiceras sp. (?)

Meekoceras sp. (?)

The thickness of this outcrop was estimated to be 200 feet; however, neither contact is exposed.

Tertiary system

Knight formation. The Knight formation was named for exposures of conglomerate and sandstone near Knight Station, Wyoming. The conglomerate was called Wasatch by Hayden (1869), but Veatch (1907) designated this conglomerate as the Knight formation of the Wasatch group. The Knight formation blankets older strata in the eastern and northeastern portions of the area. An old erosion surface is formed on top of the Knight and this feature is discussed under Geomorphology. Long, gently sloping ridges slope away from this high flat surface.

The Knight formation is a conglomerate composed of a hetrogenous assortment of phenoclasts that range in size from pebbles to boulders as much as eight feet in diameter. The most distinguishing feature of this formation is the brick-red sandy and shaly matrix. A bouldery surface, which resembles the Huntsville fanglomerate, is everywhere present as the phenoclasts are easily eroded away from the matrix. The boulders are mainly quartzites which may have been derived from either the Proterozoic or Tintic quartzites. Less common are Paleozoic limestones and sandstones. Gneisses and schists of the Farmington Canyon complex are rarely found. Along the southside of Cottonwood Creek the conglomerate erodes into pinnacles.

Fossils have not been found in the Knight formation in the Durst Mountain-Huntsville area. However, Eardley (1944) tentatively correlates the Knight of this area with that of Wyoming. Gazin (1952) concludes that the Knight formation in Wyoming is Wasatchian (Early Eocene).

<u>Norwood tuff</u>. The Norwood tuff was named by Eardley (1944) for the exposures at the mouth of Norwood Canyon in Morgan Valley. The tuff covers the western third

of the area mapped and forms a low divide between Ogden Valley and Morgan Valley. This formation erodes to small, rounded, light-gray hills. Slumping and small landslides are common; these are probably associated with the saturation of the formation. The characteristic topography and the light-gray hill slopes are useful features for the identification of the tuff on aerial photographs or in the field.

The Norwood tuff is a well stratified, fairly well indurated formation composed of clastic and pyroclastic material and some marly beds. The layers of tuff, sandstone, and shale are white, tan, green, and pink. The upper beds are friable whereas the lower beds usually have a concoidal fracture. The coarser sediments are massive. The layers of tuff are uniform in thickness and widespread but poor exposures make long distance tracing difficult. Eardley (1944) noted a compact, greenish tuff that forms a ledge over the low divide from Ogden Valley to Morgan Valley. This particular unit was shown to be a very fresh rhyodacite tuff which probably represents a volcanic dust fall in a temporary lake several miles across. On top of this tuff a cross-bedded, medium grained sandstone was observed.

Because of the poor outcrops and the absence of the basal contact, the thickness of the formation could not be estimated. Schick (1955) calculated a thickness of over 4,750 feet. The Norwood tuff was deposited on a surface of great relief. Streams carrying volcanic debris from the south and east deposited their load in lakes or on flood plains that were then in existence.

Vertebrate remains discovered by Eardley (1944) established a Lower Oligocene age for the Norwood tuff. Although the tuff cannot be traced to the Park City volcanic field, the erosional remnants between the two and the similarities of lithology indicate a possible correlation.

Huntsville fanglomerate. The Huntsville fanglomerate was first described by Ben E. Lofgren in the vicinity of Huntsville, Utah. He did not name the formation, but orally referred to it as the Huntsville, a name by which it is now generally known. This formation forms a bouldery surface over a large part of the area studied and is the cap rock of many of the hills especially in the western part. Placing the contact of the Huntsville and the underlying Norwood tuff was difficult because it has been washed down from capping deposits to form a float of pebbles and cobbles on the Norwood surface. Sampling by digging and the use of aerial photographs aided the author in placing the contact. Criteria for distinguishing the Norwood tuff on photographs were the characteristic slumping, the small rounded hills, and the light color. The Huntsville fanglomerate was also difficult to distinguish from the surface of eroded Knight conglomerate. The

Huntsville-Knight contact was arbitrarily placed at Bennett Creek. The bouldery surface typical of the fanglomerate seemed to be continuous across this area. But Knight outcrops in Cottonwood Creek and the South Fork of the Ogden River, at the edge of the Herd Mountain surface, indicate that Knight conglomerate caps the northeastern area. The Huntsville fanglomerate is covered with sage brush and grasses with very few trees or shrubs of any size except in the area between Cottonwood Creek and Durst Mountain. The bouldery surface to which the fanglomerate weathers is poor for farming and roads but the vegetation it supports is sufficient for the grazing of sheep and cattle. No outcrops where the altitude could be ascertained were observed; approximate strikes and dips were estimated from aerial photographs. The Huntsville fanglomerate is mainly a slope former. However, in several places it forms ridges that are the result of erosion.

The fanglomerate is composed of unconsolidated, rounded to sub-rounded pebbles, cobbles and boulders that are unsorted. The matrix is a brownish-red silt and sand. The phenoclasts are mainly composed of Cambrian (?) quartzites, Paleozoic limestones, and the Precambrian Farmington gneisses and schists. Generally, the quartzites predominate, but locally one of the other rock types may be the chief constituent of the fanglomerate. The bedding is obscure.

The thickness of the Huntsville fanglomerate could not be accurately determined because neither the upper nor lower contacts were discernable. However, the author would estimate a maximum thickness of several hundred feet on the evidence of the thickness of the remnants of the dissected fanglomerate. Lofgren (1955) postulates that the initial thickness was in excess of 300 feet in the area surrounding Huntsville. Schick (1955) shows a thickness of 400 $\pm$ feet immediately south of the area studied and Egbert (1954) states that the fanglomerate is probably less than 120 feet in the East Canyon area.

The fanglomerate was most likely derived from the Knight conglomerate. Eardley (1955) states, "the normal faulting that caused the deposition of the late Pliocene fanglomerate terminated, and a regimen of pediment erosion set in on the piedmont areas which in good part were the alluvial fans". The down-faulted blocks were the sites of sedimentation and the uplifted area supplied the sediments.

The lower contact was not observed in the field but the author believes that the Huntsville fanglomerate unconformably overlies the Norwood tuff. The principal evidence to substantiate this view is the discrepancies in dip that are observed on aerial photographs. Lofgren (1955) states that the fanglomerate was apparently deposited on an erosional surface of considerable relief; Schick (1955) observed that the Norwood tuff is truncated by the flat-lying Huntsville fanglomerate in Roswell Canyon, two miles south of the area studied. However, Egbert (1954) states that the fanglomerate rests with apparent conformity on the Norwood tuff in the East Canyon area but in Morgan Valley it is discordant with the underlying tuff.

The dating of the Huntsville fanglomerate is difficult, for good outcrops are scarce and no fossils are found. It is definitely post-Norwood tuff and the unlithified nature of the formation suggests a much more recent age. The fanglomerate is cut by normal faulting, but the Weber Valley erosion surface cuts across the fanglomerate (Schick, 1955). Therefore, the Huntsville fanglomerate is post-normal faulting and pre-Weber Valley erosion surface; this evidence would seem to indicate a Pliocene age. This dating agrees with Eardley (1955) who favors a Pliocene age for the fanglomerate and correlates the Harkers fanglomerate in the Jordan-Oquirrh area, and the Mink Creek conglomerate in Cache Valley with the Huntsville fanglomerate.

Quaternary system

Deposits related to Lake Bonneville. Delta and shoreline deposits related to Lake Bonneville are present in the extreme southwestern corner of the area, along the lower reaches of Cottonwood Creek, and in Ogden Valley. Pronounced shorelines can be seen east of the Monastery just north of the area and near the mouth of Cottonwood Canyon. Silts and sands, that were in part derived from the reworking of the

Norwood tuff, go to make up the shoreline deposits. A delta was formed at the confluence of Cottonwood Creek and Lake Bonneville; the contained small gravel deposits are utilized by the State Highway Commission for road construction.

Alluvial deposits. Alluvial deposits of silt, sand, and gravel are present in Ogden Valley, Morgan Valley, and along Cottonwood Creek, Bennett Creek, and Sheepherd Creek. Small deposits are also present in the fault trough west of Durst Mountain. There are talus slopes along the strike of the Tintic quartzite but these do not obscure the underlying strata.

Near Arbuckle Creek in Cottonwood Canyon remnants of an old stream profile occur. These consist of loosely consolidated, sub-angular boulders and cobbles in a matrix of poorly sorted coarse sand. This old stream profile could be related to the raised base level which was present during Lake Bonneville time.

STRUCTURE

The Durst Mountain uplift is the most pronounced structural feature within the Durst Mountain-Huntsville area. The uplift extends from the central portion of the mapped area eastward to Devil's slide and is composed of a sequence of east-dipping strata that range from the Precambrian to the Jurassic Twin Creek formation. The mapped area includes only that portion of the stratigraphic sequence from the Precambrian to the Pennsylvanian Weber quartzite. The most pronounced diastrophic movements occurred on the west where the strata have been thrust and tilted to the vertical and even overturned.

Surrounding the Durst Mountain uplift is a blanket of Tertiary strata that is a most useful aid in deciphering the history of the area. The Eocene Knight conglomerate is on the east and the Oligocene Norwood tuff, which is partially overlain by the Pliocene (?) Huntsville fanglomerate, is on the west. Cretaceous and Paleocene rocks are missing locally and, therefore, to understand the Laramide history and later events it is necessary to study the surrounding region where Cretaceous and early Cenozoic deposits occur.

Thrusts

Durst thrust. The Durst thrust strikes approximately north-south west of Durst Peak. It extends from the southern limit of the area northward and is offset by the

Spring Branch fault. North of this transverse fault the thrust continues in a sinuous pattern, and is covered by the Huntsville fanglomerate.

About 1,000 feet from the western side of the outcrop a zone of brecciated and broken quartzite indicates the trace of the thrust. The strike of the Tintic quartzite is north-south and the dips are to the east on the east side and west on the west side of the outcrop. All the dips are vertical or within a few degrees of the vertical. Here, the quartzite section is thicker than normally would be expected. To the south Schick (1955) reports that Precambrian rocks are thrust over the Tintic quartzite along the strike of the fault. This evidence is the basis for postulating the thrust. It is believed that the thrust moved westward; an additional section of quartzite was brought to the surface and in so doing, the adjacent beds were upturned and the Durst Mountain block was elevated.

The repetition of Tintic quartzite north of Bohman Hollow cannot be accounted for by block faulting because of the tremendous displacement required to depress the quartzite of Durst Mountain to this western exposure. (Eardley, 1944, p. 852). However, the thrust that connects these two areas is nowhere clearly exposed.

North of Cottonwood Creek it is believed that the Durst thrust cuts an older thrust surface (see cross section B-B'-B''). The Farmington Canyon complex is unconformably
A-A'-A''

overlain by the Tintic quartzite. Since shale beds are common, and the basal conglomerate could not be found, the lower part of the quartzite is probably absent. Thus, an older thrust could have sheared off the lower portion of the quartzite; therefore, the thrust plane would be represented by the contact of the Tintic with the Precambrian rocks. This older thrust plane is terminated on the eastern extremity by the Durst thrust.

Lack of evidence prevents the accurate dating of the Durst thrust. It is certainly pre-Spring Branch fault and is probably associated with the Laramide structures of which thrusting is a common phenomenon. It could be related to either the early Cretaceous (?) Ogden and Taylor thrusts or the Paleocene Willard thrust (Eardley, 1944).

East-west faults

General statement. A system of nearly parallel faults striking slightly north of east was observed within the area mapped. Although the fault planes could not be observed, it is believed that these are all of the normal variety. The faults are all local and terminate within the area although the stratigraphic displacement may be as much as 5,000 feet. The larger faults are the Spring Branch fault and the Bennett Creek fault; a discussion of these will follow in later paragraphs. The age of these faults cannot be placed accurately but because of the similar trend the writer has grouped them together. All the faults either are covered by the Huntsville fanglomerate at some place along their strike or disappear under the fanglomerate. Therefore, they are pre-Huntsville in age. The Bennett Creek fault and the Spring Branch fault do not appear to cut the Herd Mountain surface and, therefore, pre-date it. They possibly are of late Laramide age.

Three faults are located in the vicinity of the corner of secs. 2, 3, 10, 11, T.5N., R. 3E. The stratigraphic displacement of the larger fault on the south-east is about 800 feet where the Three Forks formation is offset into the Cambrian limestone. Movement along this fault appears to be mainly dip-slip. Two smaller faults are located north of this and are arranged in en echelon fashion with the north-west block moving down.

Spring Branch fault. The Spring Branch fault strikes slightly north of east just north of Durst Peak. North of the fault the Paleozoic strata and the Durst thrust are offset to the east. The fault disappears under the Knight formation on the east and the Huntsville fanglomerate on the west.

A pronounced alignment of springs along the fault occurs in the SE¼, sec. 23, T. 5N., R. 2. The fault is best seen east of Bohman Hollow where the Tintic quartzite abuts against the Cambrian limestone. Displacement is greatest on the west and the movement is believed to be rotational with a pivot point on the east. This pivot would be covered by the Knight conglomerate. Movement was with the north block moving up and the south block moving down. Mineralization at the head of Durst Canyon and Miller's Gulch could be associated with this fault but no evidence to show the relationship of the two was observed.

Bennett Creek fault. The Bennett Creek fault strikes slightly north of west in the vicinity of Bennett Creek. There are no surface indications of this fault, but on the south side of Bennett Creek a small outcrop of brecciated and crumpled Weber quartzite (?) is present in a roadcut. A short distance east of the Weber occurrence the Mississippian limestones crop out. North of the fault the Triassic Thaynes formation is present. Southeast of the area mapped the Weber quartzite, the Park City formation, the Woodside shale, and the Thaynes formation overlie the Mississippian limestones. If this normal sequence continues along strike with constant thickness, this fault would have a stratigraphic displacement of at least 5,000 feet. The Thaynes does not show any signs of being faulted, however, and the attitude of the strata on either side of the fault is seemingly the same. The writer is at a loss for any other possible explanation of this Triassic occurrence. The trace of the Willard thrust is a few miles to the north and the writer thought the Bennett fault might be related to this feature; but Eardley (personal communication) states that the Willard thrust veers to the southeast.

North-south faults

<u>General statement</u>. A second episode of faulting was recognized by the writer in the Durst Mountain-Huntsville area. The faults of this system trend west of north. All the faults are west of the Durst thrust and parallel approximately the strike of the thrust. The east-west Spring Branch fault terminates against the western-most of these northwesterly-trending faults. A scarp occurs in the Huntsville fanglomerate along the trace of the fault to the north.

The Huntsville fanglomerate is associated with the movement of these faults; it is believed to be the debris of the eroded uplifted blocks (Schick, 1955). Later movement along the faults led to the formation of the scarps. The relationship of the faults to the Weber Valley erosion surface which is post-Huntsville (Schick, 1955) is not evident within the mapped area, but it is concluded that most of the faulting occurred during the deposition of the fanglomerate, and a small part of it afterward. Since the fanglomerate is considered late Pliocene or early Pleistocene in age, the faulting is considered late Pliocene and Pleistocene in age.

<u>Morgan fault</u>. The Morgan fault was first recognized by Gilbert (1890). He postulated that this was a major fault that extended southward from the east side of

Cache Valley, but Eardley (1944) thinks movement along this fault is minor. The fault is one of a group of three normal faults that strike north, west of Durst Peak. The three faults form a horst and graben structure (see cross section B-B', Plate 1). The writer does not believe that the Morgan fault is as extensive as postulated by Gilbert. The Morgan fault continues south of the area and the interpretation of the structure mapped by Schick (1955) is not clear. The horst as shown in cross section B-B' (Plate 1) does not exist according to Schick who thinks the faults are in en echelon pattern. The western blocks of each are down thrown. Schick has traced the fault from Morgan northward. He has not designated the relative movement of the western-most fault. One possibility is that just south of the mapped area a pivot point exists; north of this point the west side has moved up relative to the east block.

Folds and unconformities

<u>Pre-Knight folds and unconformities</u>. The oldest recognized unconformity within the area separates the Pre-cambrian Farmington Canyon complex from the Tintic quartzite. Over 10,000 feet of Proterozoic (?) rocks are absent that are normally present in adjacent areas. During this hiatus a period of orogeny (Eardley and Hatch, 1940) of unknown duration and intensity occurred. During this period of deformation the Utah Highland probably extended into the Durst

Mountain-Huntsville area. Therefore, the writer believes that the unconformity is due to non-deposition of sediments rather than deposition with subsequent erosion.

Between the deposition of the Cambrian limestone and the Three Forks formation a second hiatus occurred. There is no apparent angular discordance between the strata and so the area was probably again the site of non-deposition. It is possible that the Proterozoic (?) highland was uplifted a second time. This hiatus was more widespread than the Proterozoic.

The dip of the Paleozoic strata is eastward and varies from the vertical in the central portion to about 40 degrees on the east. There are some variations. The increase of dip to the west is believed to be the result of deformation caused by the Durst thrust. The tilting of the Durst Mountain block probably occurred as a phase of the Laramide orogeny.

The western edge of the Knight formation outcrop laps onto the north-trending Paleozoic formations and at one time probably covered the entire area. Evidence for this is the Knight (?) capping two small hills in the north-central portion of the area. To the east of the mapped area the relatively flat-lying Knight overlies the truncated, upturned beds of the Mesozoic and Paleozoic strata.

<u>Morgan Valley syncline</u>. A syncline extends from Ogden Valley across the low divide in the western portion of

the area, and thence southward to the headwaters of Mountain Dell Creek. The syncline was delineated by Eardley (1944, p. 856) from his regional study of the north-central Wasatch Mountains.

Within the mapped area the syncline is not apparent although a small synclinal structure was mapped north of Mountain Green. This lies fairly close to the axis of the syncline as mapped by Eardley. The syncline was folded after Knight deposition (Eardley, 1944), and is probably late Eocene in age. West of the mapped area, on the east slope of the Wasatch Range, the Knight formation can be seen dipping about 30 degrees off the crest of the range. The Knight then dips under the Norwood tuff; the east flank of the syncline cannot be observed. Any evidence of this east flank was probably destroyed by the episode of north-south faulting which occurred much later than the folding of the syncline.

After folding of the Knight, part of the conglomerate was eroded. The Norwood tuff was deposited in the structural trough and an angular discordance between the two formations is reported to the south of the area by Egbert (1954). Within the area this contact was not observed.

<u>Post-Norwood folds and unconformities</u>. After deposition of the Norwood tuff a second period of folding occurred along the axis of the Morgan Valley syncline. The relationship of the tuff to the Knight formation indicates

that the Norwood dips are less than the Knight and that this is due to renewed folding and not initial dip (Eardley, 1944). After folding of the Norwood, which is Lower Oligocene, the period of north-south faulting ensued which probably destroyed the east flank of the syncline in the area mapped. Associated with the faulting was the Huntsville fanglomerate which is dated as late Pliocene (?) and early Pleistocene. Again the contact of these formations could not be observed in the field but the relationship is probably one of angular discordance.

GEOMORPHOLOGY

General statement. The Durst Mountain-Huntsville area is in the late youth stage of geomorphic development. The uplands have been completely dissected and the area is well drained. The streams are deeply incised into the uplands. The pattern of drainage is mainly dendritic but in local areas the streams are adjusted to the structure. Herd Mountain is situated at the hub of a larger radial drainage pattern which includes the area between the Ogden and Weber River. Except for that of the Weber River, no flood plains or meander belts have been developed.

Cottonwood Creek is a perennial stream which is superposed over older structural trends. Like the Weber and Ogden rivers its course was developed on the Knight conglomerate which blanketed the entire area. As the conglomerate was stripped away by erosion, the stream was "let down" and cut into the underlying rocks without regard to structure. Cottonwood Creek forms a steep canyon where it cuts perpendicularly across the Tintic quartzite. At the time of Lake Bonneville, the local base level was raised and gravels and sands were deposited in the canyon. These deposits were stripped away when the base level was again lowered by the subsidence of the lake.

The crest of a low divide between the Ogden River and Weber River is migrating slowly to the south; the more vigorous headward erosion of the Ogden River drainage is apparent.

The most interesting geomorphic forms found within the area are the ancient Herd Mountain and Weber Valley erosion surfaces. These pediment surfaces aid in diciphering the geologic history of the area.

Herd Mountain surface

The Herd Mountain surface is the highest, thus the oldest, erosion surface in the north-central Wasatch Mountains. This high plateau-like feature was named by Eardley (1944) for the beautifully preserved remnants in the vicinity of Herd Mountain. The entire northeastern part of the mapped area is beveled by this gently sloping pediment. Excellent views of the surface can be had by an observer looking eastward from the Wasatch Mountains or Snow Basin. The flat-lying Knight conglomerate underlies the surface and the beds appear to be parallel with the surface.

It is difficult to tell if a pediment gravel has formed upon the surface; if a lag gravel is present it could be easily misinterpreted as the bouldery surface which is typical of Knight erosion. The elevation of Herd Mountain is 9,100 feet and this is the highest observed altitude of the surface. In Cottonwood Canyon and South Fork Canyon (north of the area) outcrops of the Knight conglomerates are beveled by the Herd Mountain surface.

The Norwood tuff is absent from the entire eastern area and probably was never deposited there. If this area was slightly elevated during Norwood deposition, or if the

Norwood were deposited upon it, subsequent erosive activity would surely have dissected this surface to a much greater degree. The lower and younger erosion surface, the Weber Valley surface, is eroded into the Huntsville fanglomerate and the Herd Mountain surface. The Norwood tuff has been folded and if the Herd Mountain surface was in existence at this time, it surely would have been folded. Thus, the most plausible dating of the Herd Mountain surface is post-Norwood tuff and pre-Weber Valley surface. This would limit it to the late Oligocene or Miocene. The Herd Mountain surface is probably contemporaneous with the Gilbert Peak surface of Bradley (1936) although the sedimentary record of the two surfaces is different.

Weber Valley surface

Rejuvenation of the area occurred after formation of the Herd Mountain surface. As a result this older surface was greatly dissected. A second period of peneplanation then ensued. Pediments were formed along the sides of the major valleys. Because of the typical development along the Weber Valley Eardley (1944) called this the Weber Valley surface. This surface can best be seen sloping away from the high hills northeast of the town of Peterson. East of the Monastery (just outside the northern limit) the Weber Valley surface has been eroded into the Herd Mountain surface. This pediment slopes to within a few hundred feet of the valley floor.

During the interval of rejuvenation normal faulting with the subsequent deposition of the Huntsville fanglomerate took place. At this time the present drainage pattern was established. As the streams regained their vigor, a new pediment surface was eroded on the Huntsville fanglomerate and Norwood tuff. This pediment is only found associated with present drainage. The relationship of the Weber Valley erosion surface with the Huntsville fanglomerate suggests a Pliocene or Pleistocene age for the pediment.

Bonneville Lake history

During Lake Bonneville time a narrow arm of the lake extended up Weber Canyon and inundated the lower portion of Morgan Valley. Considerable deltaic material was deposited in the Morgan embayment at the mouth of Cottonwood Creek. Deposits of sand and gravel stand as remnants above the valley floor. The silt, which has been mostly eroded, was derived from the Norwood tuff. The alluvial and deltaic deposits are at an elevation of 5,175 feet in Morgan Valley (Childs, 1938) which approximates the Bonneville level of 5,200 feet. Several intermediate terraces are cut into the Norwood tuff east of the town of Mountain Green. These terraces slope into the Weber Valley surface.

Another bottle-shaped embayment was present in Ogden Valley. The shore line east of the Monastery indicates that the lake waters covered all of the southern part of the valley and probably extended slightly up the South Fork of the Ogden River.

ECONOMIC CONSIDERATIONS

The Durst Mountain-Huntsville area is mainly an agricultural district. Three-quarters of the land is used as summer range for the grazing of sheep; several thousand head are grazed annually within the area. Turkeys are raised in the lower part of Cottonwood Canyon. Small herds of cattle are grazed along Sheep Herd Creek and south of Bohman Hollow.

The only land under cultivation is in the western part of the area. A rich soil is formed from the Norwood tuff and wherever the land is level enough it is cultivated. Grain and alfalfa are the major crops; small gardens also do very well. Most of the cultivated land is restricted to the southern portion of the area. Water from Cottonwood Creek is supplied to two small reservoirs by canals. These reservoirs serve as a source of irrigation water during the summer months.

Mining once played an important role in the development of the area but now activity is reduced to the development of mining claims by a few prospectors. At the turn of the century a small mining district was established at the head of Durst Creek. Several ore shipments were made. During the recent uranium "boom" the Precambrian rocks aroused the interest of many prospectors.

If a mineral deposit were to be discovered in the vicinity of Cottonwood Creek it would be favored by a good secondary road along Cottonwood Creek to U. S. Highway 30 south or to a railroad at Mountain Green on the Union Pacific Railroad.

Argenta district

The Argenta district is located south of Cottonwood Creek at the head of Durst Creek and Miller's Gulch. The literature is somewhat confused over the naming of this district; it is referred to as either the Morgan district or the Argenta district. However, geographic locations usually given with the description of the district permit accurate location.

The district was organized in February of 1893 and the first ore shipment was made in 1905. The principal metals produced in order of importance were lead, silver and iron (Loughlin, 1920). The mines in the district according to "old timers" have been worked periodically through the years, but no known shipments were made in recent years. The writer did not enter the mines as he considered this an unsafe procedure. The following discussion of the mining district is taken from Loughlin (1920) with slight modification by the writer.

> The ore deposits of the Carbonate Hill and the Carbonate Gem mines are in the Cambrian limestones and those of the Morgan Argentine are in the Madison limestone. The ore occurs in small bunches along the bedding and along fissures of northwest, northeast, and east-west trends. The ore minerals are galena, cerusite, pyrite, and limonite; the principal gangue minerals are barite and more or less calcite. The average contents of shipments from the Carbonate Hill mine are silver, 2.7 ounces to the ton; lead, 16.9 per cent; insoluble, 17.2 per cent; zinc, 2.7 per cent; sulphur, 0.5 per cent; iron 33.4 per cent.
>
> The mineral composition of the ore, its low silver content, and the general absence of the quartz in the gangue are characteristic of ore bodies remote from intrusive igneous bodies.

The small size of the ore shoots thus far found is evidently due to the unfavorable character of the enclosing rock.

Other mining possibilities

Iron oxide is common in float at the head of Miller's Gulch, along the strike of the Cambrian limestones north of Cottonwood Creek, and north and west of Durst Peak. Prospect pits are scattered along these occurrences but none are very extensive. These areas are most likely underlain by deposits of iron oxide. The writer believes drilling will be necessary to locate and evaluate the deposits.

The pegmatites associated with the Precambrian rocks in Cottonwood Canyon are reported to contain Thorium and Yttrium by the prospectors in the area. Mica is also abundant. The presence of these three commodities has induced many prospectors to stake claims and do development work. However, the low grade of the mica and the toughness of the host rock leads the writer to conclude that mining would be uneconomical.

Sand and gravel

The delta deposits in the southwestern part of the area are composed mainly of sand and gravel. Although the deposits are comparatively small for non-metallic mineral deposits, there is a sufficient quantity of this commodity to warrant exploitation for local uses. The State

Highway Department has a small pit along U. S. Highway 30 south across from "The Wheel". Along the banks of Cottonwood Creek cobbles are gathered for use as building stones.

GEOLOGIC HISTORY

Precambrian time

The record of geologic history of the Durst Mountain-Huntsville area begins in middle (?) Precambrian time with the deposition of over 10,000 feet of sediments. During a period of prolonged orogeny the sediments were metamorphosed and injected by sills and dikes. This sequence is known as the Farmington Canyon complex.

Following the episode of metamorphism, sedimentation again ensued on a regional scale. Although more than 12,000 feet of sediments were deposited in adjacent areas, none are present in the Cottonwood Canyon area. This slightly metamorphosed sequence is Proterozoic (?). The northern Utah Highland emerged as a positive area at this time. An eastward extension of the highland is postulated to account for the absence of the Proterozoic sediments in the local area.

Cambrian

During middle and late Cambrian time a marine invasion from the west encroached upon the Utah Highland. Lithologies of the basal Cambrian formation within the Great Basin are very similar and represent the erosion products carried by streams from granitic areas to the north and east (Deiss, 1941). The wave action of the transgressive sea probably re-sorted these sediments. Because of the absence of fossils, cross-bedding, and the local concentration of rounded pebbles, it is supposed that these sediments were laid down by aggrading streams. The Tintic quartzite represents the oldest sedimentary formation within the mapped area. As the sea deepened, the finer sediments of the Ophir shale were laid down. Finally the chemical precipitates of the Upper Cambrian were deposited.

Ordovician, Silurian and Devonian

No record of Ordovician, Silurian, or lower Devonian sedimentation is present within the area. To account for the absence of these sediments, two explanations are possible: (1) an episode of erosion in early Devonian time stripped off the Ordovician and Silurian sediments, (2) a positive area of low relief was present. A combination of these would account for the absence of the sediments. The author favors the development of a positive area of low relief; perhaps this lowland persisted from Proterozoic time. Since no pronounced angular unconformities were observed, the positive area must have been of low relief and no extensive orogenic activity took place. In late Devonian time, 750 feet of predominently clastic sediments were deposited.

Edvalson (1947) indicates that a highland, which was situated between Salt Lake City and Ogden, was the source area for the clastic Three Forks (?) formation. He also indicated that open sea-ways connect the mapped area with that of the Devonian to the north. The thin limestones of the Three Forks (?) formation may be associated with these channels.

Carboniferous

From early Mississippian through early Pennsylvanian time nearly 6,000 feet of sediments were deposited; these sediments make up the Madison limestone, the Brazer formation, the Round Valley limestone, the Morgan formation, and the Weber quartzite. The Weber quartzite represents the youngest Paleozoic stratum exposed within the area.

Late Pennsylvanian through Triassic

Only a small patch of Triassic Thaynes limestone represents this long interval. To the southeast representatives of these systems are present and the writer believes that the sediments are now covered by the Knight formation in the eastern part of the area. Probably a history similar to that described by Schick (1955), for the area to the south, is true for the Durst Mountain-Huntsville area. The Thaynes limestone represents a marine invasion during Triassic time.

Cretaceous

No record of Cretaceous rocks is present within the mapped area. However, regional studies show the uplift of frontal Wasatch occurred in early Cretaceous time.

The Durst thrust could be associated with this thrusting.

Tertiary

Paleocene time. The period of Cretaceous thrusting was followed by the Willard thrust. Since evidence for the dating of the Durst thrust was not found, it is possible that the Durst thrust may be associated with the Willard thrust. Probably the Durst Mountain block was elevated at this time. Uplift of the region to the west shed coarse conglomerates in adjacent areas.

Eocene time. Continued uplift to the west led to the deposition of the Knight formation. Egbert (1954) reports that the underlying Almy strata were folded and tilted prior to the deposition of the knight. Over 5,000 feet of Knight conglomerate was deposited.

After deposition of the Knight formation, the Laramide activity subsided. The Morgan Valley syncline was flooded in late Eocene time and the present day relief features began to form.

Oligocene and Miocene events. In early Oligocene time, vulcanism broke out in the Park City area. Streams carried the volcanic material into the structural depressions, and thus, the Norwood tuff was deposited. Following deposition of the Norwood tuff, the Herd Mountain surface was eroded. Also, the east-west episode of faulting occurred.

Pliocene time. The north-south episode of normal faulting gave rise to the coarse clastics of the Huntsville fanglomerate. Renewed uplift caused erosion of the Weber Valley surface; dissection of this surface might have carried into Pleistocene time.

Pleistocene and recent events. The Weber Valley surface was eroded further and was followed by the invasion of Lake Bonneville into Morgan and Ogden Valleys. Terraces were cut and a delta was formed during the stay of the lake. Local base level was raised and when the lake retreated, the lowered base level caused incision of most of the rivers and streams of the area.

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